

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference 116842.6 LK	FOR FURTHER ACTION		See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
International application No. PCT/IL99/00431	International filing date (day/month/year) 05/08/1999	Priority date (day/month/year) 05/08/1998	
International Patent Classification (IPC) or national classification and IPC G01B11/24			
Applicant CAIDENT LTD. et al.			

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.
2. This REPORT consists of a total of 5 sheets, including this cover sheet.

This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

These annexes consist of a total of 8 sheets.

3. This report contains indications relating to the following items:

- I Basis of the report
- II Priority
- III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- IV Lack of unity of invention
- V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- VI Certain documents cited
- VII Certain defects in the international application
- VIII Certain observations on the international application

Date of submission of the demand 29/02/2000	Date of completion of this report 29.08.00
Name and mailing address of the international preliminary examining authority:  European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Mielke, W Telephone No. +49 89 2399 2661



**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT**

International application No. PCT/IL99/00431

I. Basis of the report

1. This report has been drawn on the basis of (substitute sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments.):

Description, pages:

1-14 as originally filed

Claims, No.:

1-37 as received on 11/09/2000 with letter of 11/09/2000

Drawings, sheets:

1/5-5/5 as originally filed

2. The amendments have resulted in the cancellation of:

- the description, pages:
- the claims, Nos.:
- the drawings, sheets:

3. This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

4. Additional observations, if necessary:

III. Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

The questions whether the claimed invention appears to be novel, to involve an inventive step (to be non-obvious), or to be industrially applicable have not been examined in respect of:

the entire international application.

claims Nos. 35,37,

because:

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EXAMINATION REPORT**

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the said international application, or the said claims Nos. relate to the following subject matter which does not require an international preliminary examination (*specify*):

the description, claims or drawings (*indicate particular elements below*) or said claims Nos. are so unclear that no meaningful opinion could be formed (*specify*):

see separate sheet

the claims, or said claims Nos. are so inadequately supported by the description that no meaningful opinion could be formed.

no international search report has been established for the said claims Nos. .

IV. Lack of unity of invention

1. In response to the invitation to restrict or pay additional fees the applicant has:
 - restricted the claims.
 - paid additional fees.
 - paid additional fees under protest.
 - neither restricted nor paid additional fees.
2. This Authority found that the requirement of unity of invention is not complied and chose, according to Rule 68.1, not to invite the applicant to restrict or pay additional fees.
3. This Authority considers that the requirement of unity of invention in accordance with Rules 13.1, 13.2 and 13.3 is
 - complied with.
 - not complied with for the following reasons:

see separate sheet
4. Consequently, the following parts of the international application were the subject of international preliminary examination in establishing this report:
 - all parts.
 - the parts relating to claims Nos. .

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT**

International application No. PCT/IL99/00431

V. Reasoned statement under Article 35(2) with regard to novelty, inventiv step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims 1-34,36
	No:	Claims
Inventive step (IS)	Yes:	Claims 1-34,36
	No:	Claims
Industrial applicability (IA)	Yes:	Claims 1-34,36
	No:	Claims

2. Citations and explanations

see separate sheet

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT - SEPARATE SHEET**

International application No. PCT/IL99/00431

Item V:

Independent claims 1,18,32,36 relate to apparatus for determining surface topology of a teeth portion. They all comprise a probing member, an illumination unit for providing an array of incident light beams, light focusing optics, a translation mechanism, a detector, and a processor. In claim 1 a mirror with a central aperture is used, and in claim 18 the illumination unit comprises at least two light sources. In claim 32 the probing member is in the form of a specially elongated transparent body, and in claim 36 a transparent plate is fixed with an air gap to an elongated transparent body. Such special embodiments are not indicated with existing used arrays of light beams in a confocal measuring mode. Accordingly claims 1-34,36 are regarded to meet the criteria of article 33(2-4) PCT.

Item IV:

The linking concept of the above four embodiments is a confocal array of light beams. But this is indicated in figure 25 of EP-A1-679864, using a pinhole array PHA1, column 2 lines 9-27. Accordingly the requirement of unity of invention is not met, rule 13.1 PCT.

Item III:

In claims 35,37 probing members for use in claimed apparatus are stated. No features of the probing members are given, so that an opinion is not possible.

CLAIMS:

1. An apparatus for determining surface topology of a teeth portion, comprising:
 - a probing member with a sensing end face for placing proximal to the teeth portion;
 - an illumination unit for providing an array of incident light beams transmitted towards the teeth portion along an optical path through said probing unit to generate illuminated spots on said portion;
 - a light focusing optics defining one or more focal planes forward said end face at a position changeable by said optics, each light beam having its focus on one of said focal planes;
 - a translation mechanism for displacing the focal planes relative to the teeth portion along an axis defined by the propagation of the incident light beams;
 - a detector having an array of sensing elements for measuring intensity of each of a plurality of imaging light beams returning from said spots propagating along an optical path opposite to that of the incident light beams;
 - a mirror disposed between said illumination unit and said light focusing optics, the mirror having a central aperture and being capable of passing said incident light beams towards said light focusing optics and of reflecting said imaging light beams towards said detector by an area of the mirror surrounding said aperture;
 - a processor coupled to said detector for determining for each light beam a spot-specific position, being the position of the respective focal plane of said one or more focal planes yielding maximum measured intensity of the returned light beam, and based on the determined spot-specific positions, generating data representative of the topology of said portion.
2. An apparatus according to Claim 1, wherein said probing member is in the form of an elongated transparent body having a front face, an end mirror and top, bottom and side walls extending therebetween, said

sensing end face being associated with said bottom wall's outer surface adjacent said end mirror, said bottom wall having a front section extending inwardly from said front face transversely to said top wall and a rear section substantially co-directional with said top wall, said front face being inclined relative to said top wall so as to ensure that the beams incident on the front face perpendicularly thereto impinge said top wall at an angle providing their total internal reflection therefrom and their further bouncing, by means of total internal reflection between the top wall and said rear section of the bottom wall towards said end mirror to be redirected thereby towards said sensing end face.

15 3. An apparatus according to Claim 2, wherein said sensing end face is in the form of a transparent plate fixed to said bottom wall's outer surface and spaced therefrom by an air gap.

4. The apparatus according to Claim 1, wherein said illumination unit comprises a source emitting a parent light beam and a beam splitter for splitting the parent beam into said array of incident light beams.

5. The apparatus according to Claim 4, wherein said illumination unit comprises a grating or microlens array.

20 6. The apparatus according to any one of Claims 1 – 5, comprising a polarizer for polarizing said incident light beams are polarized.

7. The apparatus according to Claim 6, comprising a polarization filter for filtering out from the returned light beams light components having the polarization of the incident light beams.

25 8. The apparatus according to any one of Claims 1 – 7, wherein the illumination unit comprises at least two light sources and each of said incident beams is composed of light components from the at least two light sources.

9. The apparatus according to Claim 8, wherein the at least two light sources emit light component of different wavelengths.

30 10. The apparatus according to Claim 9, wherein said light focusing optics defines a different focal plane for each light component and the detector independently detects intensity of each light component.

11. The apparatus according to Claim 8, wherein the at least two light sources are located so as to define optical paths of different lengths for the incident light beams emitted by each of the at least two light sources.
- 5 12. The apparatus according to any one of Claims 1 – 11, wherein said focusing optics operates in a telecentric confocal mode.
13. The apparatus according to any one of Claims 1 – 12, wherein said light focusing optics comprises optical fibers.
- 10 14. The apparatus according to any one of Claims 1 – 13, wherein said sensing elements are an array of charge coupled devices (CCD).
15. The apparatus according to Claim 14, wherein said detector unit comprises a pinhole array, each pinhole corresponding to one of the CCDs in the CCD array.
16. The apparatus according to any one of Claims 1 – 15, comprising a unit for generating data for transmission to CAD/CAM device.
17. The apparatus according to Claim 16, comprising a communication port of a communication medium.
18. An apparatus for determining surface topology of a teeth portion, comprising:
 - 20 - a probing member with a sensing end face for placing proximate to the teeth portion;
 - an illumination unit comprising at least two light sources emitting light of different wavelength for providing an array of incident light beams each composed of light components from said at least two light sources, for transmitting said beams towards the teeth portion along an optical path through said probing member to generate illuminated spots on said portion;
 - a light focusing optics defining a focal plane for each of said light components of each light beam forward said sensing end face at a position changeable by said optics;
 - a translation mechanism for displacing said focal plane relative to the teeth portion along said optical path;
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- a detector having an array of sensing elements for measuring intensity of each light component of each of a plurality of imaging light beams returning from said spots propagating through an optical path opposite to that of the incident light beams;
- a processor coupled to said detector for determining, for each light component of each light beam, a spot-specific position being the position of the respective focal plane of yielding maximum measured intensity of the imaging light beam, and based on the determined spot-specific positions, generating data representative of the topology of teeth portion.
- 19. The apparatus according to Claim 18, wherein said illumination unit further comprises a beam splitter for splitting parent beams emitted by said light sources into said array of incident light beams.
- 20. The apparatus according to Claim 19, wherein said illumination unit comprises a grating or microlens array.
- 21. The apparatus according to any one of Claims 18 – 20, comprising a polarizer for polarizing said incident light beams are polarized.
- 22. The apparatus according to Claim 21, comprising a polarization filter for filtering out from the imaging light beams light components having the polarization of the incident light beams.
- 23. The apparatus according to any one of Claims 18 – 22, wherein said focusing optics operates in a telecentric confocal mode.
- 24. The apparatus according to any one of Claims 18 – 23, wherein said light focusing optics comprises optical fibers.
- 25. 25. The apparatus according to any one of Claims 18 – 24, wherein said sensing elements are an array of charge coupled devices (CCD).
- 26. The apparatus according to Claim 25, wherein said detector unit comprises a pinhole array, each pinhole corresponding to one of the CCDs in the CCD array.
- 30 27. The apparatus according to any one of Claims 18 – 26, comprising a unit for generating data for transmission to CAD/CAM device.

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28. The apparatus according to Claim 27, comprising a communication port of a communication medium.
29. An apparatus according to any one of Claims 18 - 28, further including a mirror disposed between said illumination unit and said light focusing optics, the mirror having a central aperture and being capable of passing said incident light beams towards said light focusing optics and of reflecting said imaging light beams towards said detector by an area of the mirror surrounding said aperture.
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30. An apparatus according to any one of Claims 18 - 29, wherein said probing member is in the form of an elongated transparent body having a front face, an end mirror and top, bottom and side walls extending therebetween, said sensing end face being associated with said bottom wall's outer surface adjacent said end mirror, said bottom wall having a front section extending inwardly from said front face transversely to said top wall and a rear section substantially co-directional with said top wall, said front face being inclined relative to said top wall so as to ensure that the beams incident on the front face perpendicularly thereto impinge said top wall at an angle providing their total internal reflection therefrom and their further bouncing, by means of total internal reflection between the top wall and said rear section of the bottom wall towards said end mirror to be redirected thereby towards said sensing end face.
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31. An apparatus according to Claim 30, wherein said sensing end face is in the form of a transparent plate fixed to said bottom wall's outer surface and spaced therefrom by an air gap.
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32. An apparatus for determining surface topology of a teeth portion, comprising:
 - a probing member with a sensing end face for placing proximal to the teeth portion;
 - an illumination unit for providing an array of incident light beams transmitted towards the teeth portion along an optical path through said probing unit to generate illuminated spots on said portion;
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- a light focusing optics defining one or more focal planes forward said end face at a position changeable by said optics, each light beam having its focus on one of said focal planes;
- a translation mechanism for displacing the focal planes relative to the teeth portion along an axis defined by the propagation of the incident light beams;
- a detector having an array of sensing elements for measuring intensity of each of a plurality of imaging light beams returning from said spots propagating along an optical path opposite to that of the incident light beams;
- a processor coupled to said detector for determining for each light beam a spot-specific position, being the position of the respective focal plane of said one or more focal planes yielding maximum measured intensity of the returned light beam, and based on the determined spot-specific positions, generating data representative of the topology of said portion;
- said probing member being in the form of an elongated transparent body having a front face, an end mirror, and top, bottom and side walls extending therebetween, said sensing end face being associated with said bottom wall's outer surface adjacent said end mirror, said bottom wall having a front section extending inwardly from said front face transversely to said top wall and a rear section substantially co-directional with said top wall, said front face being inclined relative to said top wall so as to ensure that light beams incident on the front face perpendicularly thereto impinge said top wall at an angle providing their total internal reflection therefrom and further bouncing, by means of total internal reflection, between the top wall and said rear section of the bottom wall towards said end mirror to be redirected thereby towards said sensing end face.

30 33. An apparatus according to Claim 32, wherein said sensing end face is in the form of a transparent plate fixed to said bottom wall's outer surface and spaced therefrom by an air gap.

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34. An apparatus according to Claim 32 or 33, wherein said probing member, as seen in its side view, has a thickness that is essentially greater along said front section of the bottom wall than along said rear section of the bottom wall.
- 5 35. A probing member for use in an apparatus according to any one of Claim 32, 33 and 34.
36. An apparatus for determining surface topology of a teeth portion, comprising:
 - a probing member with a sensing end face for placing proximal to the teeth portion;
 - an illumination unit for providing an array of incident light beams transmitted towards the teeth portion along an optical path through said probing unit to generate illuminated spots on said portion;
 - a light focusing optics defining one or more focal planes forward said end face at a position changeable by said optics, each light beam having its focus on one of said focal planes;
 - a translation mechanism for displacing the focal planes relative to the teeth portion along an axis defined by the propagation of the incident light beams;
 - a detector having an array of sensing elements for measuring intensity of each of a plurality of imaging light beams returning from said spots propagating along an optical path opposite to that of the incident light beams;
 - a processor coupled to said detector for determining for each light beam a spot-specific position, being the position of the respective focal plane of said one or more focal planes yielding maximum measured intensity of the returned light beam, and based on the determined spot-specific positions, generating data representative of the topology of said portion;
 - 25 - said probing member being in the form of an elongated transparent body having a front face, an end mirror, and top, bottom and side walls extending therebetween, said sensing end face being in the form of a

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transparent plate fixed to said bottom wall's outer surface and spaced therefrom by an air gap.

37. A probing member for use in an apparatus according to Claim 36.

INTERNATIONAL SEARCH REPORT

International Application No
PCT/IL 99/00431

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G01B11/24 A61C13/00 A61C19/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G01B A61C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 679 864 A (KOMATSU) 2 November 1995 (1995-11-02) column 2, line 9 - line 27; figure 25 ----	1, 18
X	GB 2 321 517 A (YOKOGAWA) 29 July 1998 (1998-07-29) figures 3,6,7 ----	1-3, 18-21
A	DE 196 38 758 A (RUBBERT) 19 March 1998 (1998-03-19) figure 4 ----	1, 18
A	US 4 575 805 A (MOERMANN ET AL.) 11 March 1986 (1986-03-11) column 9, line 61 -column 10, line 42 ----	13 -/-

Further documents are listed in the continuation of box C.

Patent family members are listed in annex.

* Special categories of cited documents :

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- "&" document member of the same patent family

Date of the actual completion of the international search

30 November 1999

Date of mailing of the international search report

06/12/1999

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INTERNATIONAL SEARCH REPORT

International Application No	
PCT/IL 99/00431	

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	GB 2 144 537 A (ISTITUTO) 6 March 1985 (1985-03-06) page 2, line 26 - line 49; figure 2 ----	5,23
A	US 5 737 084 A (TAKAOKA) 7 April 1998 (1998-04-07) figures 5-7 ----	20
A	DE 196 50 391 A (LEICA) 10 June 1998 (1998-06-10) figure 1 ----	
A	DE 196 40 495 A (LEICA) 9 April 1998 (1998-04-09) figure 1 ----	
A	WO 97 37264 A (KOMATSU) 9 October 1997 (1997-10-09) figure 1 ----	
A	US 5 381 236 A (OXFORD SENSOR) 10 January 1995 (1995-01-10) column 3, line 21 - line 44; figure 1 -----	

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No	
PCT/IL 99/00431	

Patent document cited in search report	Publication date	Patent family member(s)			Publication date
EP 0679864 A	02-11-1995	US 5659420 A	19-08-1997		
		WO 9509346 A	06-04-1995		
		JP 7181023 A	18-07-1995		
GB 2321517 A	29-07-1998	NONE			
DE 19638758 A	19-03-1998	AU 4111497 A	02-04-1998		
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		EP 0935736 A	18-08-1999		
US 4575805 A	11-03-1986	AT 14073 T	15-07-1985		
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		JP 3017494 B	08-03-1991		
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GB 2144537 A	06-03-1985	IT 1198660 B	21-12-1988		
		DE 3428593 A	14-02-1985		
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		EP 0943113 A	22-09-1999		
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		DE 69207176 D	08-02-1996		
		DE 69207176 T	04-07-1996		
		EP 0571431 A	01-12-1993		
		WO 9214118 A	20-08-1992		
		JP 6505096 T	09-06-1994		
		JP 6506287 T	14-07-1994		

PATENT COOPERATION TREATY

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

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NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Rule 71.1)

Date of mailing
(day/month/year)

29.09.00

Applicant's or agent's file reference
116842.6 LK

IMPORTANT NOTIFICATION

International application No.
PCT/IL99/00431

International filing date (day/month/year)
05/08/1999

Priority date (day/month/year)
05/08/1998

Applicant
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1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.
2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.
3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.

4. REMINDER

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices) (Article 39(1)) (see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

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